

**FOUNDATION INVESTIGATION AND DESIGN REPORT
JACKPINE RIVER BRIDGE REHABILITATION
HIGHWAY 17, PATIENCE TOWNSHIP
THUNDER BAY UNORGANIZED DISTRICT
G.W.P. 465-00-00, STRUCTURE NO. 48C-15**

Geocres Number: 42D-29

**Report to
McCormick Rankin Corporation**

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the location of the bridge carrying Highway 17 over Jackpine River in Patience Township, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the bridge site and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile, cross-sections, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

In the preparation of this report and in addition to the boreholes drilled under the current assignment, reference has been made to information on subsurface conditions contained in a previous foundation report. The title of this report is listed as follows:

- Foundation Investigation for Jackpine River Crossing, T.C.H. No. 17, District No. 19, W.P. 944-58, prepared by Trow Soderman and Associates, Dated November 21, 1958. (Reference 1).

2 SITE DESCRIPTION

The site is located on Highway 17 approximately 24 Km east of Nipigon, Ontario. The bridge is approximately 550 m east of Karma Road in Patience Township, Thunder Bay Unorganized District, Ontario.

At the bridge location, Highway 17 is a two-lane paved roadway. The existing Jackpine River Bridge is a single-span structure with a total length of 24.4 m supported on two abutments. The abutments are supported on spread footings founded on native soils. The width of the bridge is 11.4 m.



At the site, the Jackpine River flows from north to south.

The lands immediately surrounding the bridge site consist of forested areas. A steep exposed scarp is observed on the north side of the bridge. The river channel is lined with cobbles and boulders, more noticeable along the edges of the channel. Rock fill protection is also observed surficially at the abutments.

Photographs in Appendix D show the general nature of the surrounding land.

The site lies within the Canadian Shield, characterized by low, rounded hills of Pre-Cambrian bedrock mantled by varying thicknesses of overburden. At this site, the overburden primarily consists of glaciofluvial outwash deposits: gravel and sand.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out on February 5 to 8, 25 and 26, 2011. A total of four sampled boreholes (numbered JPR-01 to JPR-04) were drilled to depths ranging from 12.7 m to 18.3 m (elevations 189.6 to 184.7). Dynamic Cone Penetration Tests (DCPTs) were also performed from the bottom of Boreholes JPR-01, JPR-03 and JPR-04 extending to depths ranging from 12.8 m to 22.4 m.

Two DCPTs were also performed from 3.1 m to 5.4 m depth and from 3.1 m to 12.0 m depth adjacent to Boreholes JPR-02 and JPR-03, respectively. The DCPTs were conducted to supplement the data/information collected from the boreholes.

The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing in Appendix F. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendix A. The co-ordinates and ground surface elevations of the boreholes were obtained from plan drawings provided by MRC.

Boreholes JPR-02 and JPR-03 were drilled just behind the approach slab at the abutments. Boreholes JPR-01 and JPR-04 were drilled through the west and east approach embankments.

Records of Boreholes 1 to 4 drilled during the previous investigation, (Reference 1) and the associated Borehole Location Plan are included in Appendix C.

Prior to commencement of the current drilling program, utility clearances were obtained for all borehole locations.

Hollow stem augers and wash-boring with casing were used to advance the boreholes. Coring techniques were required at various depths in Borehole JPR-02 to advance the boreholes through zones of cobbles and boulders present in the native sand and gravel deposits. Samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and prepared the samples for transport back to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. The boreholes were backfilled with auger cuttings to 0.05 m, then cold patch asphalt to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer). The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A stratigraphic profile is presented on the Borehole Locations and Soil Strata Drawing in Appendix F, for illustrative purposes. Overall descriptions of the stratigraphy are given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general terms, the soil stratigraphy encountered at this site consists of asphalt over gravelly sand to sand and gravel fill overlying native deposits of sand and gravel to sand. Auger grinding noted at various depths and the occasional use of coring techniques to advance the boreholes, indicate the presence of cobbles and boulders within the native cohesionless deposits. More detailed descriptions of the individual strata are presented below.

Boreholes 1 to 4 drilled in 1958, revealed native medium to coarse gravel with stones and boulders up to 0.9 m in diameter over sand.

5.1 Asphalt

Asphalt was encountered at surface in all the boreholes. The thickness of the asphalt ranged from 90 mm to 150 mm.

5.2 Granular Fill

Granular embankment fill consisting of brown gravelly sand and sand and gravel containing trace silt and clay was encountered below the asphalt at the approach.

The thickness of the granular fill ranged from 3.3 m to 4.2 m.

The depth to the base of the granular fill ranged from 3.4 m to 4.3 m (Elevations 199.9 to 198.0).

SPT 'N' values recorded in the gravelly sand and sand and gravel fill ranged from 17 blows for 0.3 m penetration to 70 blows for 0.05 m penetration, indicating a compact to very dense condition

Cobbles and boulders are likely present within the fill, which may account for some high blow counts and grinding of the drill augers.

Moisture contents of the granular fill ranged from 2% to 11%.

Grain size distribution curves for three samples of the granular fill are presented on Figures B1 and B2, Appendix B. These results are also presented on the Record of Borehole sheets in Appendix A and are summarized as follows:

| | |
|---------------|----------|
| Gravel % | 22 to 42 |
| Sand % | 51 to 71 |
| Silt & Clay % | 5 to 7 |

5.3 Sand and Gravel

Native brown sand and gravel was encountered below the granular fill in Boreholes JPR-01, JPR-02, and JPR-04 at depths ranging from 3.4 m to 4.0 m (elevations 198.0 to 199.9). The sand and gravel layer contains trace silt and clay with occasional cobbles and boulders. The thickness of the sand and gravel layer ranged from 3.3 m to 4.9 m.

Two isolated layers of sand and gravel were encountered within a sand deposit in Borehole JPR-03 at 9.1 m depth and 15.0 m depth (elevations 193.8 and 188.0). The thicknesses of these layers were 0.7 m and 1.3 m.

The depth to the base of the sand and gravel layer varied from 7.3 m to 8.7 m (elevations 193.6 to 195.7) in Boreholes JPR-01, JPR-02, and JPR-04

SPT 'N' values recorded in this layer ranged from 11 blows for 0.3 m penetration to 100 blows for 0.1 m penetration, indicating a compact to very dense condition. In Borehole JPR-02, coring techniques were required to advance the borehole from 5.9 m to 7.1 m depth due to the presence of cobbles and boulders. Grinding of the drill augers was noted at various depths during borehole advancement through the sand and gravel layer, also indicating presence of cobbles and boulders.

Moisture contents in this layer ranged from 5% to 13%.

The results of grain size distribution analyses conducted on samples of the sand and gravel are presented on the Record of Borehole sheets in Appendix A and on Figure B4 of Appendix B. The results are summarized as follows:

| | |
|---------------|----------|
| Gravel % | 35 to 38 |
| Sand % | 56 to 59 |
| Silt & Clay % | 6 |

5.4 Sand

Native sand was encountered below the sand and gravel layer in Boreholes JPR-01, JPR-02, and JPR-04 and directly below the embankment fill in Borehole JPR-03. The sand is brown to reddish brown, typically medium to coarse grained, and contains trace gravel to gravelly, trace silt and clay and occasional cobbles. In Borehole JPR-03, layers of sand and gravel were encountered within the sand. The thickness of the sand layer ranges from 5.5 m to 8.1 m in Boreholes JPR-01, JPR-02 and JPR-04. The thickness of the sand layer including the interlayers of sand and gravel in Borehole JPR-03 is 14.0.

All boreholes were terminated upon refusal in the sand layer at depths ranging from 12.8 m to 18.3 m (elevations 184.7 to 189.6).

SPT 'N' values recorded in the sand ranged from 11 blows for 0.3 m penetration to 100 blows for 0.28 m penetration, indicating a compact to very dense condition.

Grinding of the drill augers was noted at various depths in Borehole JPR-03, drilled at the east abutment, indicating presence of cobbles and boulders.

Moisture contents of the sand samples ranged from 6% to 23%.

The results of grain size distribution analyses conducted on samples of the sand are presented on the Record of Borehole sheets in Appendix A and on Figure B3 of Appendix B. The results are summarized as follows:

| | |
|---------------|----------|
| Gravel % | 2 to 18 |
| Sand % | 76 to 96 |
| Silt & Clay % | 2 to 7 |

5.5 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling.

Water levels were measured at depths ranging from 5.9 m to 7.4 m (elevations 195.8 to 196.1) in Boreholes JPR-01, JPR-03 and JPR-04.

The water level in Jackpine River was at elevation 197.1 m in January 2011 (from preliminary General Arrangement drawing).

Fluctuations of the groundwater level and river level are to be expected and subject to seasonal conditions. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The groundwater level is expected to fluctuate in conjunction with variations in the river water level.

6 MISCELLANEOUS

The borehole locations were established in the field by Thurber Engineering. The coordinates and ground surface elevations at the boreholes were subsequently determined by MMM Group Limited survey personnel.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling Ltd. supplied a truck-mounted drill rig and conducted the drilling, sampling and in-situ testing operations.

The field program was supervised on a full time basis by Mr. Ryan Kromer, E.I.T and Rory McAllister of Thurber Engineering Ltd. Overall supervision of the field program was provided by Mr. Alastair E. Gorman, P.Eng. and Mr. Tony Harte, M.Sc.

Interpretation of the data and preparation of the report was carried out by Ms. Rocío Palomeque Reyna, P.Eng. and Ms. Lindsey Blaine, E.I.T. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for the proposed rehabilitation of the existing Jackpine River Bridge on Highway 17.

The existing bridge is a single span structure with a total length of 24.4 m and width of 11.4 m. The General Arrangement drawing for the existing bridge indicates that the west and east abutments are supported on spread footings founded on native soils. The footing base elevation is 193.2 at the west abutment and 193.5 at the east abutment. The abutment footings are u-shape in plan and sketches of footing plan and elevation showing the length and width of the footing are attached at the end of the text. The footing length is approximately 11.4 m and the footing width ranges from 3.8 m to 6.3 m.

Rehabilitation of the bridge will include removal of the existing concrete deck, steel girders, ballast walls and top of wingwalls, modification of the abutments and placement of a new deck comprising precast prestressed voided slab girder and a new deck. Based on information provided by the designers McCormick Rankin Corporation (MRC), the SLS vertical load per abutment will increase from 9,200 kN to 10,023 kN (an increase of 8.9%) resulting from construction of the new deck and girder. No grade raise is proposed at this site.

The discussions and recommendations presented in this report are based on the factual data obtained during the course of the investigation. The plans and profiles used for preparation of this report were provided by McCormick Rankin Corporation.

8 ASSESSMENT OF EXISTING ABUTMENT FOUNDATION

In general terms, the stratigraphy encountered at the site consists of asphalt over compact to very dense cohesionless embankment fill (gravelly sand and sand and gravel) overlying native deposits of compact to very dense sand and gravel and sand containing cobbles and boulders.



Water levels measured at the site range from 5.9 m to 7.4 m depth (elevations 195.8 to 196.1). GA indicates that water level in the Jackpine River was at elevation 197.1 m in January 2011.

Based on archive drawings, the abutments are supported on spread footings founded on native compact to dense sand/sand and gravel near elevation 193.2 to 193.5. The footing length is approximately 11.4 m and the width of the u-shaped footing ranges from 3.8 m to 6.3 m. The superstructure replacement will increase the abutment loads by 8.9%.

Based on the above footing size and depth of embedment, the following geotechnical resistances are recommended for the foundation sand/sand and gravel to assess the adequacy of the existing abutment footings to carry the additional load due to superstructure replacement:

- Factored geotechnical resistance of 700 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 325 kPa at Serviceability Limit States (SLS)

The geotechnical reaction at SLS takes into consideration the completion of elastic settlement in the cohesionless foundation soils under the existing bridge loads.

The 1958 report recommended a safe footing pressure of 3 tons/sq.ft (approx. 300 kPa).

The resistance values provided are for a vertical, concentric load. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

Information from McCormick Rankin Corporation indicates the following increases in the bearing pressures at the toe of the footings due to superstructure replacement:

| | Existing Bridge | | After superstructure replacement | |
|-------------------------|-----------------|--------------|----------------------------------|--------------|
| | ULS (kPa) | SLS (kPa) | ULS (kPa) | SLS (kPa) |
| Bearing pressure at toe | 670 | 305 | 700 | 325 |

The above bearing pressures include the effect of lateral earth pressure.

Both the ULS and SLS values reported above after superstructure replacement meet the factored ULS and SLS resistance of the foundation soils. The incremental settlement of the foundation soils due to the 8.9% increase in the SLS vertical load per abutment is estimated to be minimal, in the order of 3 to 5 mm.

Based on the above assessment, the 8.9% increase in vertical load on the abutments due to the superstructure replacement is not expected to impact the performance of the existing foundations provided the foundations are structurally adequate.

The lateral resistance of the footings may be computed using an unfactored friction coefficient of 0.5 on sand/gravel. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

8.1 Frost Cover

The depth of frost penetration at this site is 2.5 m. The existing footings appear to have sufficient cover as protection against frost action.

9 ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

Any new backfill to the abutment walls should be in accordance with OPSS 902. Granular backfill should be placed to the extents shown in OPSD 3101.150. All granular material should meet the specifications of OPSS 1010 as amended by Special Provision 110S13. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS 501.

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K(\gamma h + q)$$

where: p_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see Table 9.1)

γ = unit weight of retained soil (see Table 9.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are given in Table 9.1.

Table 9.1 – Earth Pressure Coefficients (K)

| Condition | Earth Pressure Coefficient (K) | | | |
|-------------------------------|---|-----------------------------|--|-----------------------------|
| | OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$ | | OPSS Granular B Type I Existing sand and gravel fill, native sand and gravel $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$ | |
| | Horizontal Surface Behind Wall | Sloping Backfill (2H:1V) | Horizontal Surface Behind Wall | Sloping Backfill (2H:1V) |
| Active (Unrestrained Wall) | 0.27 | 0.38* | 0.31 | 0.46* |
| At Rest (Restrained Wall) | 0.43 | - | 0.47 | - |
| Passive | 3.7 | - | 3.3 | - |

* For wing walls.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 9.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or at a depth of 1.7 m for Granular A or Granular B Type II.

10 SCOUR AND EROSION CONTROL

Generally, erosion and scour protection should be provided along the lower parts of any slopes that may be in contact with the river flow.

At this site, it appears that the native cobbles and boulders along the river bed and at the bottom of the river banks have provided erosion protection. It is recommended to reinstate the erosion and scour protection at locations where it is needed.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

11 EXCAVATION AND GROUNDWATER CONTROL

Excavation for modification of the abutments is expected to be limited to the existing gravelly sand and sand and gravel backfill adjacent to the structure. It must be noted that cobbles and boulders were encountered within the existing embankment fill.

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand fill above the water level is classified as a Type 3 soil and Type 4 soils below the water table.

It is expected that work at the abutments will not require excavation below the groundwater level. However, if construction of the new abutments involves excavation below the creek water level, dewatering will be required. The design of the dewatering system should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility.

The Contractor should be prepared to pump from sumps to remove any seepage water or surface water collecting in an excavation.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902.

12 ROADWAY PROTECTION

The bridge construction will be done in stages in order to keep at least one highway lane operational. Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

The roadway protection system selected will be installed through the embankment granular fill containing cobbles and boulders. It may be difficult to install sheet piles through the fill layer containing cobbles and boulders and therefore not recommended. Soldier piles installed through embankment fill may be a better option.

The ultimate choice of a roadway protection system should be left to the Contractor.

The following parameters apply for design of the temporary shoring system:

| | | | |
|------------|---|----------------------|--|
| γ | = | 21 kN/m ³ | (bulk unit weight) |
| γ_w | = | 11 kN/m ³ | (submerged unit weight under groundwater table) |
| K_a | = | 0.31 | (Active pressure coefficient for: road embankment fill and native soils) |
| K_p | = | 3.3 | (Passive pressure coefficient for: road embankment fill and native soils) |
| h_w | = | 197.1 | (water level elevation) |

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.

The design of roadway protection should be the responsibility of the Contractor. All shoring systems should be designed by a Professional Engineer experienced in such designs.

13 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.0
- Acceleration Related Seismic Zone 0
- Zonal Acceleration Ratio 0.0
- Peak Horizontal Acceleration 0.02

The soil profile type has been classified as Type II. Therefore, according to Table 4.4.6.1 of the CHBDC, respective Site Coefficients “S” (ground motion amplification factor) of 1.2 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, design of the existing retaining structures should be checked using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 12.1 may be used:

Table 12.1 – Earth Pressure Coefficients for Earthquake Loading

| Condition | Earth Pressure Coefficient (K) | |
|------------------------|---|--|
| | OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$ | OPSS Granular B Type I, Existing sand and gravel fill, native sand and gravel $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$ |
| Active (K_{AE})* | 0.28 | 0.32 |
| Passive (K_{PE}) | 3.7 | 3.2 |
| At Rest (K_{OE})** | 0.45 | 0.50 |

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

The foundation soils at the site are assessed as not being prone to liquefaction.

14 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Roadway protection must be provided to maintain traffic during construction. Temporary shoring systems should be properly designed by a Professional Engineer experienced in such designs.

- Installation of sheet piles for roadway protection through the existing fill containing cobbles may be difficult and hence sheet piles are not recommended.

15 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Ms. R. Palomeque Reyna and Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



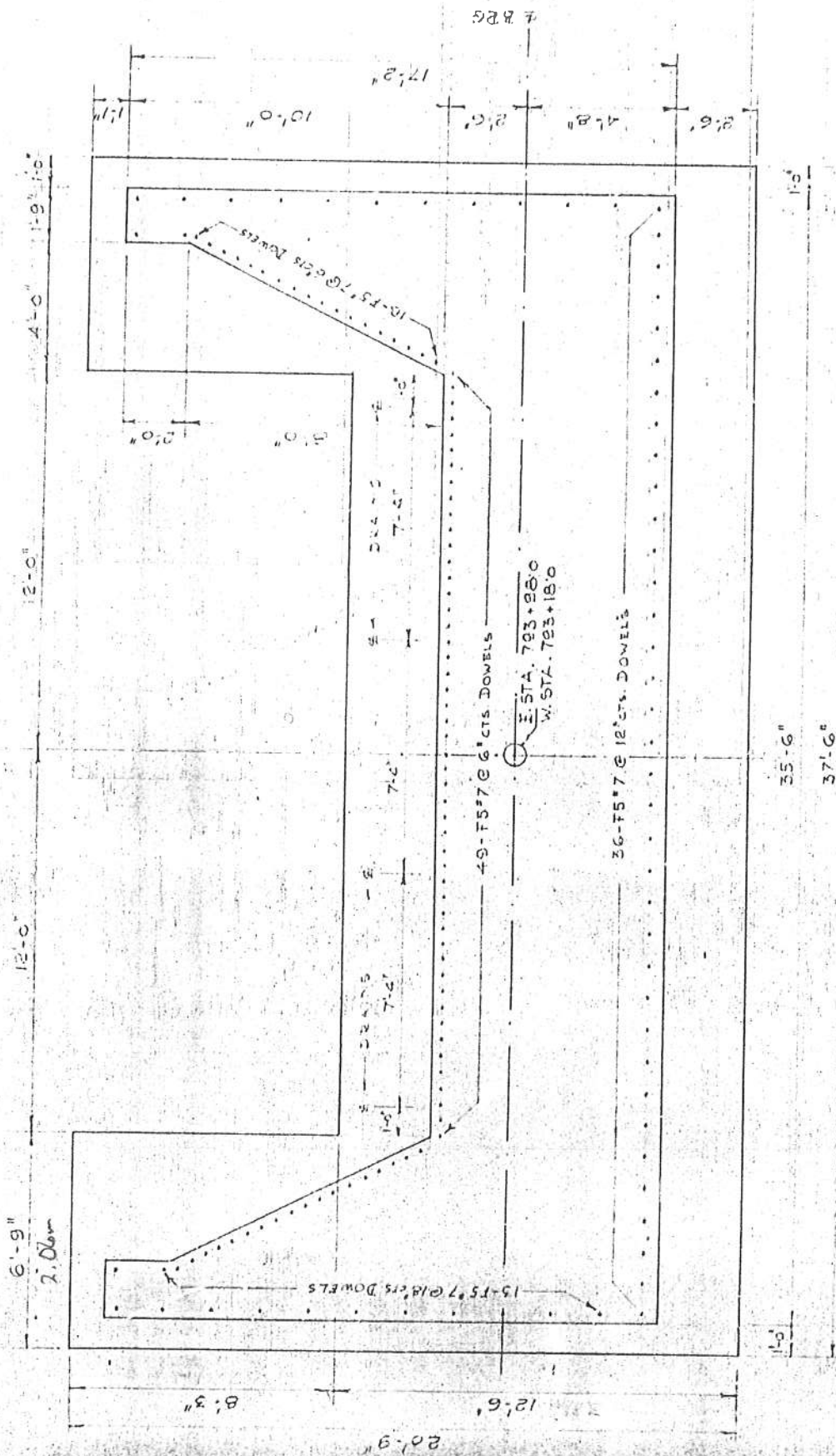
Murray R. Anderson, P.Eng., M.Eng.
Senior Foundations Engineer



P.K. Chatterji, P.Eng., Ph.D.
Review Principal



SYM



FOOTING PLAN

SCALE: 1/4" = 1'-0"

Appendix A
Record of Borehole Sheets
(Current Investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

| CLASSIFICATION | PARTICLE SIZE | VISUAL IDENTIFICATION |
|----------------|--------------------|---|
| Boulders | Greater than 200mm | same |
| Cobbles | 75 to 200mm | same |
| Gravel | 4.75 to 75mm | 5 to 75mm |
| Sand | 0.075 to 4.75mm | Not visible particles to 5mm |
| Silt | 0.002 to 0.075mm | Non-plastic particles, not visible to the naked eye |
| Clay | Less than 0.002mm | Plastic particles, not visible to the naked eye |

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

| TERMINOLOGY | PROPORTION |
|---------------------------------|---------------|
| Trace or Occasional | Less than 10% |
| Some | 10 to 20% |
| Adjective (e.g. silty or sandy) | 20 to 35% |
| And (e.g. sand and gravel) | 35 to 50% |

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| DESCRIPTIVE TERM | UNDRAINED SHEAR STRENGTH (kPa) | APPROXIMATE SPT ⁽¹⁾ 'N' VALUE |
|------------------|--------------------------------|--|
| Very Soft | 12 or less | Less than 2 |
| Soft | 12 to 25 | 2 to 4 |
| Firm | 25 to 50 | 4 to 8 |
| Stiff | 50 to 100 | 8 to 15 |
| Very Stiff | 100 to 200 | 15 to 30 |
| Hard | Greater than 200 | Greater than 30 |

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

| DESCRIPTIVE TERM | SPT 'N' VALUE |
|------------------|-----------------|
| Very Loose | Less than 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very Dense | Greater than 50 |

5. LEGEND FOR RECORDS OF BOREHOLES

| SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE | SS Split Spoon Sample | WS Wash Sample | AS Auger (Grab) Sample |
|---|---|--|------------------------|
| | TW Thin Wall Shelby Tube Sample | TP Thin Wall Piston Sample | |
| | PH Sampler Advanced by Hydraulic Pressure | PM Sampler Advanced by Manual Pressure | |
| | WH Sampler Advanced by Self Static Weight | RC Rock Core | SC Soil Core |

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


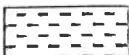



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

| MAJOR DIVISIONS | | GROUP SYMBOL | TYPICAL DESCRIPTION |
|----------------------|---------------------------------|--------------|--|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS | GW | Well-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GP | Poorly-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS | SW | Well-graded sands or gravelly sands, little or no fines. |
| | | SP | Poorly-graded sands or gravelly sands, little or no fines. |
| | | SM | Silty sands, sand-silt mixtures. |
| | | SC | Clayey sands, sand-clay mixtures. |
| FINE GRAINED SOILS | SILTS AND CLAYS $W_L < 50\%$ | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. $(W_L < 30\%)$. |
| | | CI | Inorganic clays of medium plasticity, silty clays. $(30\% < W_L < 50\%)$. |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILTS AND CLAYS $W_L > 50\%$ | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of medium to high plasticity, organic silts. |
| | HIGHLY ORGANIC SOILS | | Pt |
| CLAY SHALE | | | |
| SANDSTONE | | | |
| SILTSTONE | | | |
| CLAYSTONE | | | |
| COAL | | | |

EXPLANATION OF ROCK LOGGING TERMS

| <u>ROCK WEATHERING CLASSIFICATION</u> | | <u>SYMBOLS</u> | |
|---------------------------------------|---|---|-------------------|
| Fresh (FR) | No visible signs of weathering. | | |
| Fresh Jointed (FJ) | Weathering limited to the surface of major discontinuities. |  | CLAYSTONE |
| Slightly Weathered (SW) | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material. |  | SILTSTONE |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable. |  | SANDSTONE |
| Highly Weathered (HW) | Weathering extends throughout the rock mass and the rock is partly friable. |  | COAL |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved. |  | Bedrock (general) |

| <u>DISCONTINUITY SPACING</u> | | <u>STRENGTH CLASSIFICATION</u> | | |
|------------------------------|-----------------------|--------------------------------|---|--|
| Bedding | Bedding Plane Spacing | Rock Strength | Approximate Uniaxial Compressive Strength (MPa) | Field Estimation of Hardness* |
| Very thickly bedded | Greater than 2m | Extremely Strong | Greater than 250 | Specimen can only be chipped with a geological hammer |
| Thickly bedded | 0.6 to 2m | | | |
| Medium bedded | 0.2 to 0.6m | Very Strong | 100-250 | Requires many blows of geological hammer to break |
| Thinly bedded | 60mm to 0.2m | | | |
| Very thinly bedded | 20 to 60mm | Strong | 50-100 | Requires more than one blow of geological hammer to break |
| Laminated | 6 to 20mm | | | |
| Thinly Laminated | Less than 6mm | Medium Strong | 25.0 to 50.0 | Breaks under single blow of geological hammer. |
| | | Weak | 5.0 to 25.0 | Can be peeled by a pocket knife with difficulty |
| | | Very Weak | 1.0 to 5.0 | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| | | Extremely Weak (Rock) | 0.25 to 1.0 | Indented by thumbnail |

| <u>TERMS</u> | |
|-------------------------------------|--|
| Total Core Recovery: (TCR) | Core recovered as a percentage of total core run length. |
| Solid Core Recovery: (SCR) | Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. |
| Rock Quality Designation: (RQD) | Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length. |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen |
| Fracture Index: (FI) | Frequency of natural fractures per 0.3m of core run. |

RECORD OF BOREHOLE No JPR-01

1 OF 2

METRIC


W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 927.1 E 231 718.2 ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.08 - 2011.02.08 CHECKED BY RPR

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL | | | |
|---------------|--|------------|---------|------|---------------|----------------------------|-----------------|---|----|--------------|-----|--|--|-------------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | WATER CONTENT (%) | | |
| | | | | | | | | ○ UNCONFINED | | + FIELD VANE | | | | Wp | | |
| 202.0 | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 0.0 | ASPHALT: (100mm) | | | | | | | | | | | | | | | |
| 0.1 | SAND and GRAVEL, trace silt and clay Very Dense to Compact Brown Moist (FILL) | | 1 | AS | | | | | | | | | | | | |
| | | | 1 | SS | 100 | | | | | | | | | | | |
| | Auger grinding at 1.5m | | 2 | SS | 62/ 0.075 | | | | | | | | | | | |
| | | | 3 | SS | 26 | | | | | | | | | | | |
| | Auger grinding at 3.1m | | 4 | SS | 17 | | | | | | | | | | | |
| 198.0 | Auger grinding at 4.0m | | | | | | | | | | | | | | | |
| 4.0 | SAND and GRAVEL, trace silt and clay Compact to Very Dense Brown Wet | | 5 | SS | 100/ 0.100 | | | | | | | | | | | |
| | Layer of cobbles from 5.1m to 5.7m | | | | | | | | | | | | | | | |
| | Auger grinding at 5.5m | | | | | | | | | | | | | | | |
| | | | 6 | SS | 31 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 194.7 | | | | | | | | | | | | | | | | |
| 7.3 | SAND, medium to coarse grained, some gravel, trace silt and clay Compact to Very Dense Brown Wet | | 7 | SS | 34 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 63 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

METRIC

| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | PLASTIC LIMIT | NATURAL MOISTURE CONTENT | LIQUID LIMIT | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|------------------------------|-------------|--------|------|-------------------------|-----------------|---|-----------------|--------------------------|--------------|--|---------------------------------------|
| ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | | | "n" VALUES | 20 40 60 80 100 | w _p | w | | |
| | Continued From Previous Page | | | | | |  | | | | | |
| | | | | | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100 | | | | | |

[illegible]

+ 3, x 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No JPR-02

1 OF 2

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 922.8 E 231 734.8 ORIGINATED BY RDM
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.25 - 2011.02.26 CHECKED BY RPR

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|------------------------------------|-------------------------------------|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 40 60 80 100 | PLASTIC LIMIT w _p | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w _L | |
| 202.3 | | | | | | | | | | | | |
| 0.0 | ASPHALT: (150mm) | | | | | | | | | | | |
| 0.2 | SAND and GRAVEL, trace silt and clay Dense to Very Dense Brown Damp (FILL) | | 1 | SS | 75/ 0.075 | | 202 | | | | | |
| | | | 2 | SS | 70/ 0.050 | | | | | | | |
| | | | 3 | SS | 50 | | | | | | | |
| | | | 4 | SS | 44 | | | | | | | |
| | | | 5 | SS | 75 | | | | | | | |
| 198.5 | SAND and GRAVEL, trace silt and clay Dense Brown Moist | | 6 | SS | 41 | | | | | | | |
| 3.8 | | | | | | | | | | | | |
| | Cored through boulders and cobbles from 5.9m to 7.1m Boulder (380mm) | | | | | | | | | | | |
| | Wet | | | | | | | | | | | |
| 193.6 | SAND, some gravel, trace silt and clay Compact Reddish Brown Wet | | 8 | SS | 29 | | | | | | | |
| 8.7 | | | | | | | | | | | | |

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No JPR-02

2 OF 2

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 922.8 E 231 734.8 ORIGINATED BY RDM
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.25 - 2011.02.26 CHECKED BY RPR

| SOIL PROFILE | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|--------|------|----------------------------|-----------------|--|--|--|--|--|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | SHEAR STRENGTH kPa | | | | | | |
| | | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | |
| | | | | | | | 20 40 60 80 100 WATER CONTENT (%) | | | | | | |
| | | | | | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L | | | | | | |
| | Continued From Previous Page | | | | | | | | | | | | |
| | SAND, some gravel, trace silt and clay Compact to Very Dense Brown Wet | | 9 | SS | 81 | 192 | | | | | | | |
| | | | | | | 191 | | | | | | | |
| | | | 10 | SS | 11 | 190 | | | | | | | |
| | | | | | | 189 | | | | | | | |
| | | | 11 | SS | 31 | 188 | | | | | | | |
| | | | | | | 187 | | | | | | | |
| | | | 12 | SS | 56 | 186 | | | | | | | |
| 185.6 | Cored from 16.6m to 16.8m | | | | | | | | | | | | |
| 16.8 | END OF BOREHOLE AT 16.8m UPON AUGER REFUSAL. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.05m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | |

3 90 7
(SI+CL)

+³ ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No JPR-03

1 OF 3

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 897.2 E 231 769.3 ORIGINATED BY RK
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.02.05 - 2011.02.06 CHECKED BY RPR

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|------------------------------------|-------------------------------------|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 40 60 80 100 | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | |
| 203.0 | | | | | | | | | | | | |
| 0.0 | ASPHALT: (90mm) | | | | | | | | | | | |
| 0.1 | Gravelly SAND, trace silt and clay Compact to Very Dense Brown Moist (FILL) Auger grinding at 0.9m, 1.4m and 3.8m | | 1 | AS | | | | | | | | |
| | | | 1 | SS | 70 | | | | | | | |
| | | | 2 | SS | 51/ 0.125 | | | | | | | |
| | | | 3 | SS | 22 | | | | | | | |
| | | | 4 | SS | 18 | | | | | | | |
| | Cobbles at 3.8m | | | | | | | | | | | |
| 198.7 | | | | | | | | | | | | |
| 4.3 | SAND, trace gravel to gravelly, trace silt and clay, occasional cobbles Compact to Very Dense Brown Moist to Wet | | 5 | SS | 28 | | | | | | | |
| | Auger grinding at 5.8m | | | | | | | | | | | |
| | Wet DCPT refusal at 6.3m | | 6 | SS | 63 | | | | | | | |
| | Auger grinding at 7.0m and 8.5m | | 7 | SS | 34 | | | | | | | |
| 193.8 | | | | | | | | | | | | |
| 9.1 | SAND and GRAVEL Compact Brown Wet | | 8 | SS | 11 | | | | | | | |
| 193.2 | | | | | | | | | | | | |
| 9.8 | | | | | | | | | | | | |

Continued Next Page

+³, x³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No JPR-03

2 OF 3

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 897.2 E 231 769.3 ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.05 - 2011.02.06 CHECKED BY RPR

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|--------------|----------------------------|-----------------|--|-----------------|--|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 80 100 | | |
| | Continued From Previous Page | | | | | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L | | |
| | SAND, some gravel to gravelly, trace silt and clay, occasional cobbles Very Dense Brown Wet | | 9 | SS | 61 | | 193 | | | | | |
| | DCPT refusal at 12.0m | | 10 | SS | 57 | | 192 | | | | | |
| | Compact | | 11 | SS | 13 | | 191 | | | | | |
| 188.0 | | | | | | | 190 | | | | | |
| 15.0 | SAND and GRAVEL, trace silt and clay Very Dense Brown Wet | | 12 | SS | 66 | | 189 | | | | | |
| 186.7 | | | | | | | 188 | | | | | |
| 16.3 | SAND, some gravel Very Dense Brown Wet | | 13 | SS | 100/ 0.28 | | 187 | | | | | |
| 184.7 | | | | | | | 186 | | | | | |
| 18.3 | End of sampling at 18.3m and start DCPT | | | | | | 185 | | | | | |
| | | | | | | | 184 | | | | | |

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No JPR-03

3 OF 3

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 897.2 E 231 769.3 ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.05 - 2011.02.06 CHECKED BY RPR

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | PLASTIC LIMIT W _P | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| | Continued From Previous Page | | | | | | | 20 40 60 80 100 | | 20 40 60 | | | GR SA SI CL | |
| | | | | | | | 183 | | | | | | | |
| | | | | | | | 182 | | | | | | | |
| | | | | | | | 181 | | | | | | | |
| 180.6 | | | | | | | | | | | | | | |
| 22.4 | END OF BOREHOLE AND DCPT AT 22.4m UPON AUGER REFUSAL. WATER LEVEL AT 7.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND AUGER CUTTINGS TO 0.05m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | | |

+³ . X³ : Numbers refer to Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No JPR-04

1 OF 2

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 892.8 E 231 785.8 ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.07 - 2011.02.07 CHECKED BY RPR

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------------|--|------------|---------|------|--------------|----------------------------|-----------------|---|-----------------|-----------------|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | 20 40 60 80 100 | 20 40 60 80 100 | 20 40 60 80 100 | | |
| 203.3 0.0 0.1 | ASPHALT: (90mm) Gravelly SAND, trace silt and clay Compact Brown Moist (FILL) | | 1 | SS | 116/ 0.23 | | 203 | | | | | 22 71 6 (SI+CL) |
| | | | 2 | SS | 40 | | 202 | | | | | |
| | | | 3 | SS | 34 | | 201 | | | | | |
| 199.9 3.4 | SAND and GRAVEL, occasional cobbles Compact to Very Dense Brown Moist Auger grinding at 4.0m and 5.5m | | 4 | SS | 18 | | 200 | | | | | |
| | | | 5 | SS | 24 | | 199 | | | | | |
| | | | 6 | SS | 103 | | 198 | 150 | | | | |
| | Auger grinding at 6.7m | | | | | | 197 | | | | | |
| 195.7 7.6 | SAND, medium grained, trace to some gravel, trace silt and clay Compact to Very Dense Brown Wet | | 7 | SS | 40 | | 196 | | | | | |
| | | | 8 | SS | 18 | | 195 | | | | | |
| | | | | | | | 194 | | | | | |

Continued Next Page

+³, X³: Numbers refer to
Sensitivity 20
15-5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No JPR-04

2 OF 2

METRIC

W.P. 465-00-00 LOCATION Jackpine River Bridge N 5 426 892.8 E 231 785.8 ORIGINATED BY RK
HWY 17 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.02.07 - 2011.02.07 CHECKED BY RPR

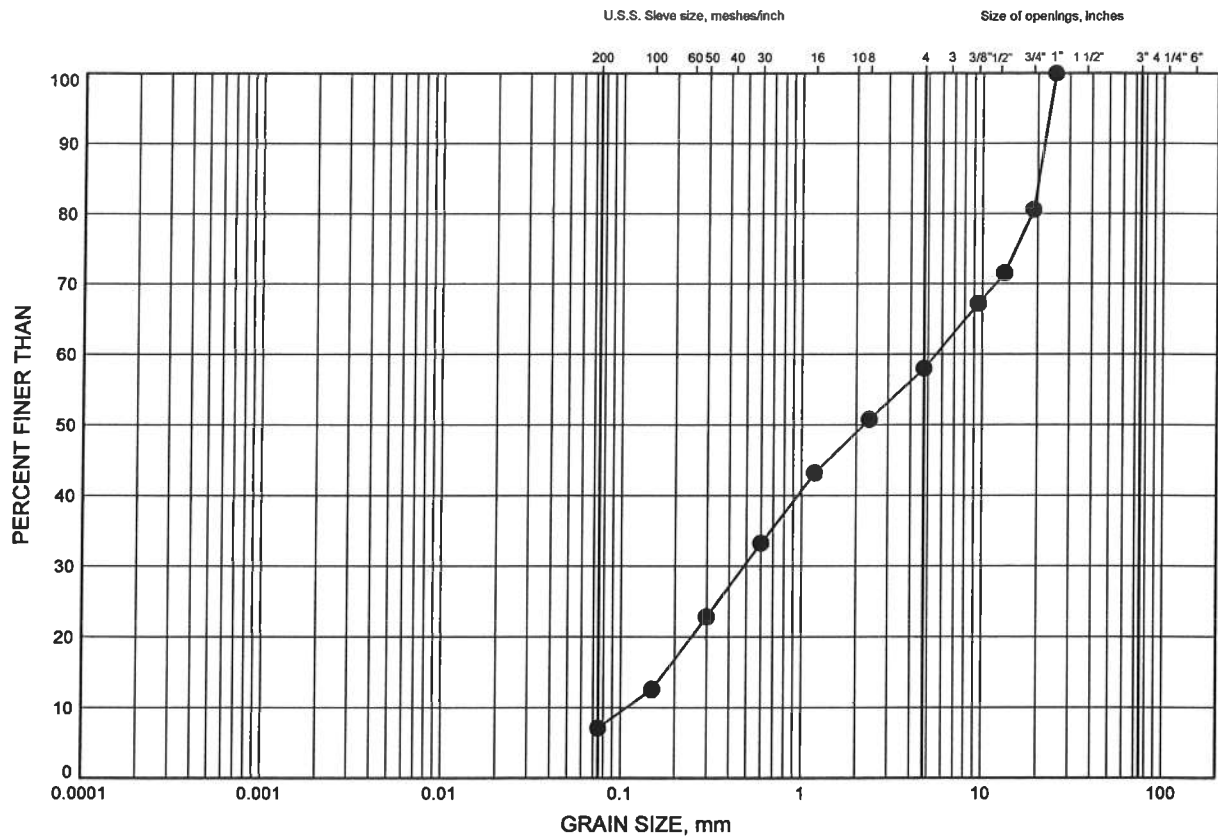
| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | PLASTIC LIMIT W _p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W _L | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | WATER CONTENT (%) | | | | |
| | Continued From Previous Page | | | | | | | 20 40 60 80 100 | | | | | | | | |
| | SAND, trace gravel, trace silt and clay Compact to Very Dense Brown Wet | | 9 | SS | 16 | | 193 | | | | | | | | | |
| | | | | | | | 192 | | | | | | | | | |
| | | | 10 | SS | 53 | | 191 | | | | | | | | | |
| | End of sampling at 12.8m and start DCPT | | | | | | 190 | | | | | | | | | |
| 189.6 | | | | | | | | | | | | | | | | 2 96 2 (SI+CL) |
| 13.7 | END OF BOREHOLE AND DCPT AT 13.7m UPON AUGER REFUSAL. WATER LEVEL AT 7.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.05m, THEN ASPHALT TO SURFACE. | | | | | | | | | | | | | | | |

Appendix B
Laboratory Test Results
(Current Investigation)

NWR 32 Rehabs GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & GRAVEL FILL



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | JPR-02 | 2.59 | 199.74 |

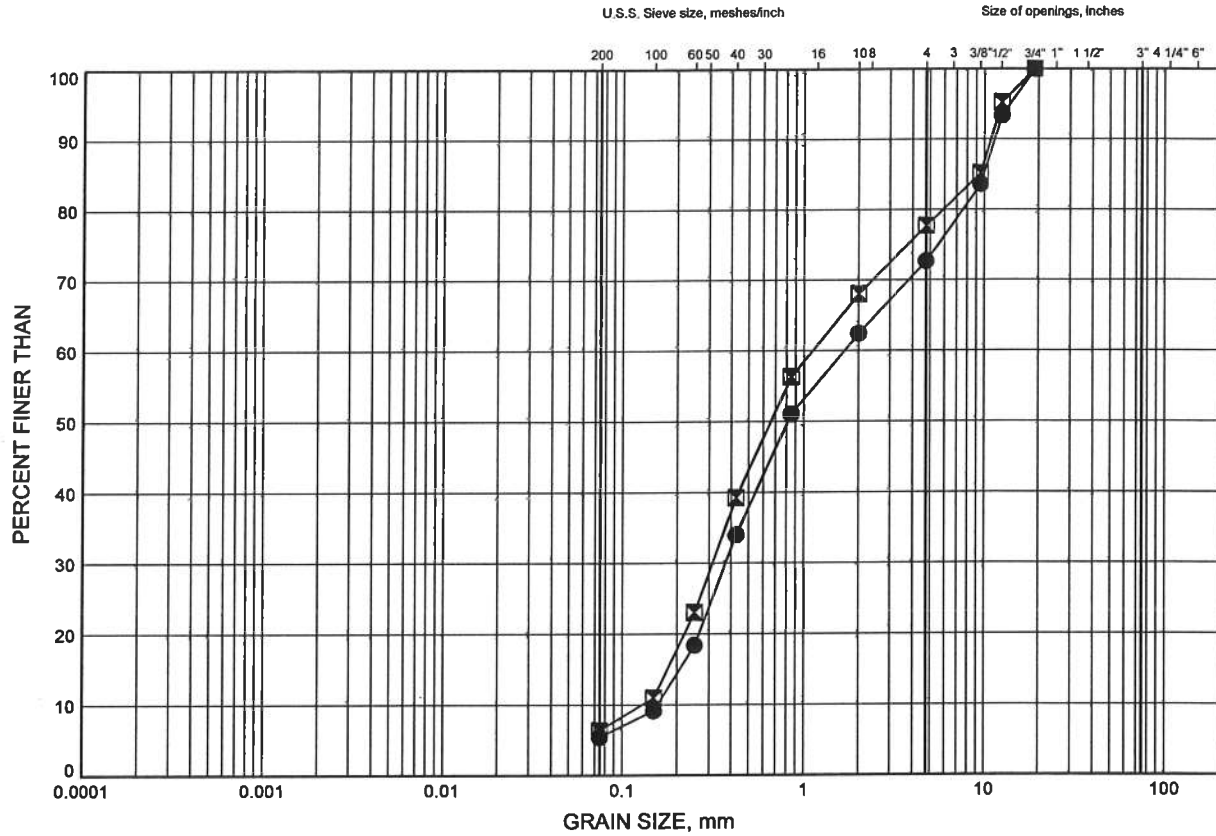


W.P.# 465-00-00
Prepared By AN
Checked By RPR

NWR 32 Rehabs GRAIN SIZE DISTRIBUTION

FIGURE B2

GRAVELLY SAND FILL



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | JPR-03 | 3.35 | 199.63 |
| ⊠ | JPR-04 | 2.59 | 200.71 |

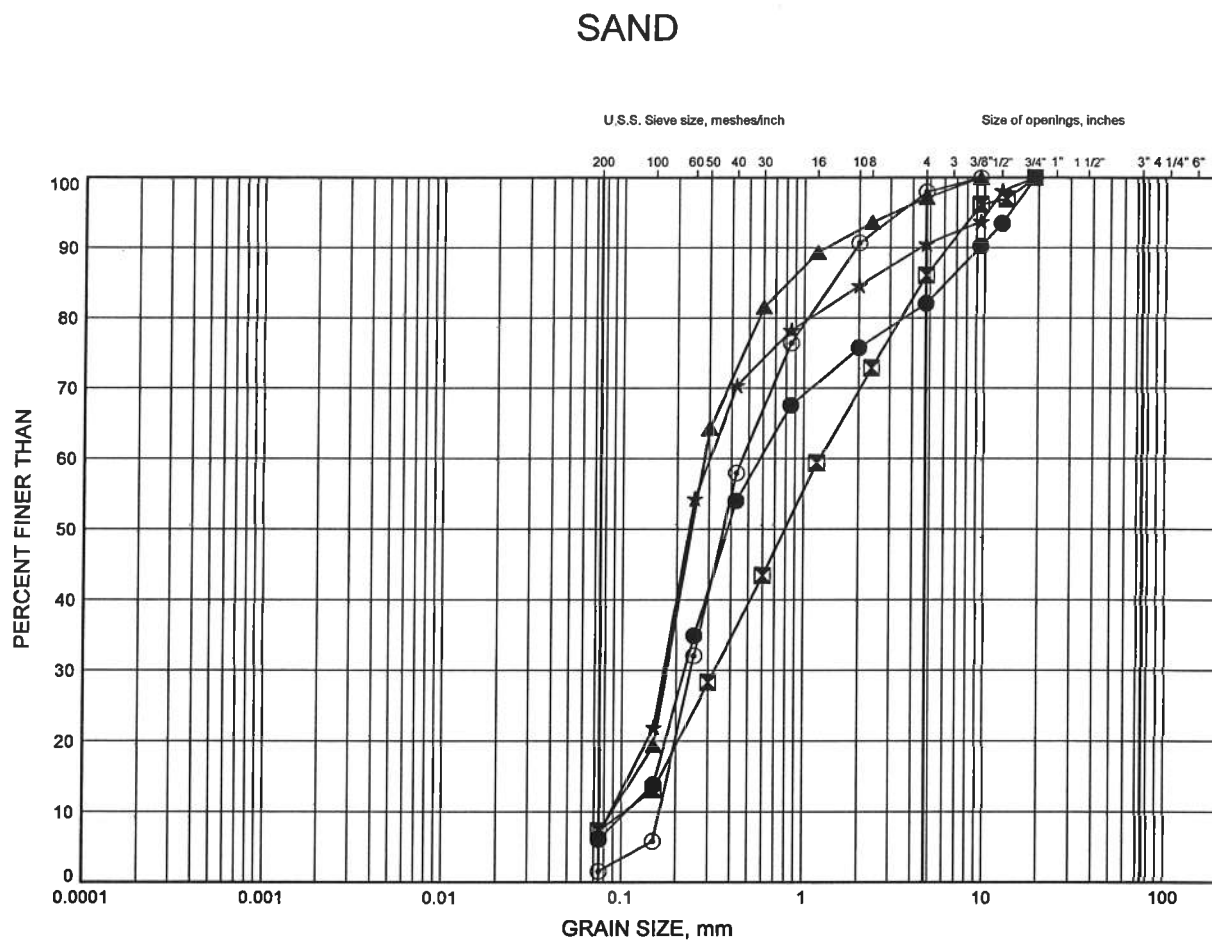


W.P.# 465-00-00
Prepared By AN
Checked By RPR

NWR 32 Rehabs

GRAIN SIZE DISTRIBUTION

FIGURE B3



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | JPR-01 | 9.45 | 192.56 |
| ⊠ | JPR-02 | 9.45 | 192.88 |
| ▲ | JPR-02 | 14.02 | 188.31 |
| ★ | JPR-03 | 7.92 | 195.05 |
| ⊙ | JPR-04 | 12.50 | 190.80 |

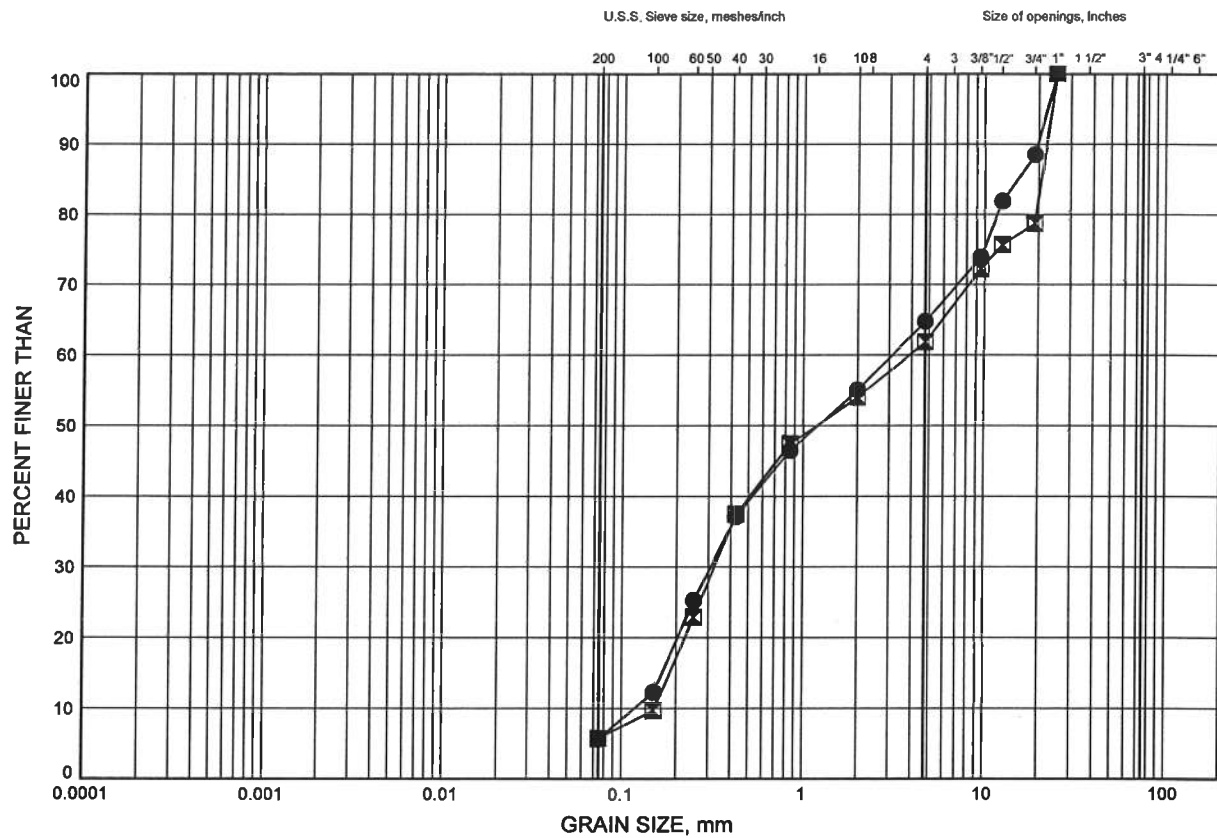


W.P.# .465-00-00.....
 Prepared By .AN.....
 Checked By .RPR.....

NWR 32 Rehas GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND & GRAVEL



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

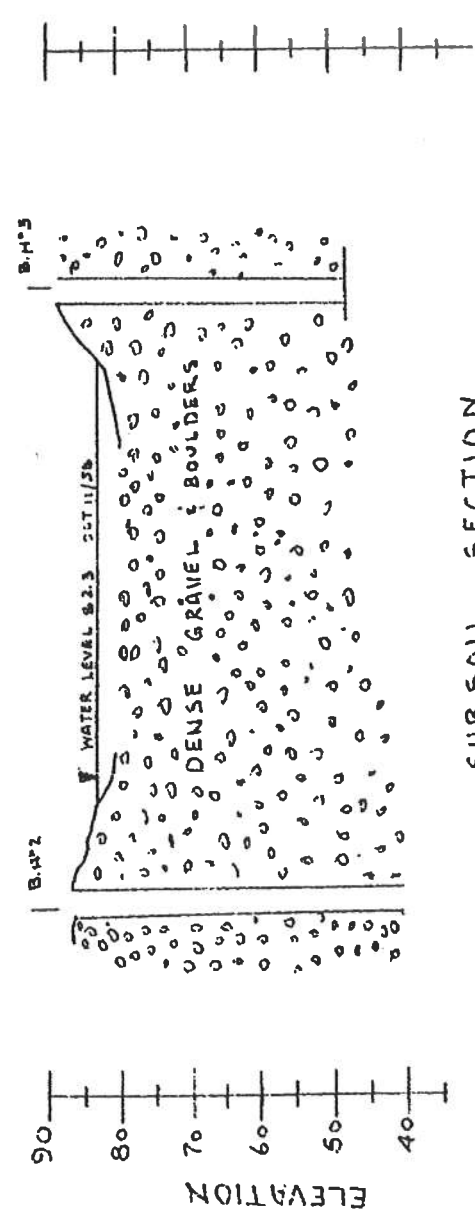
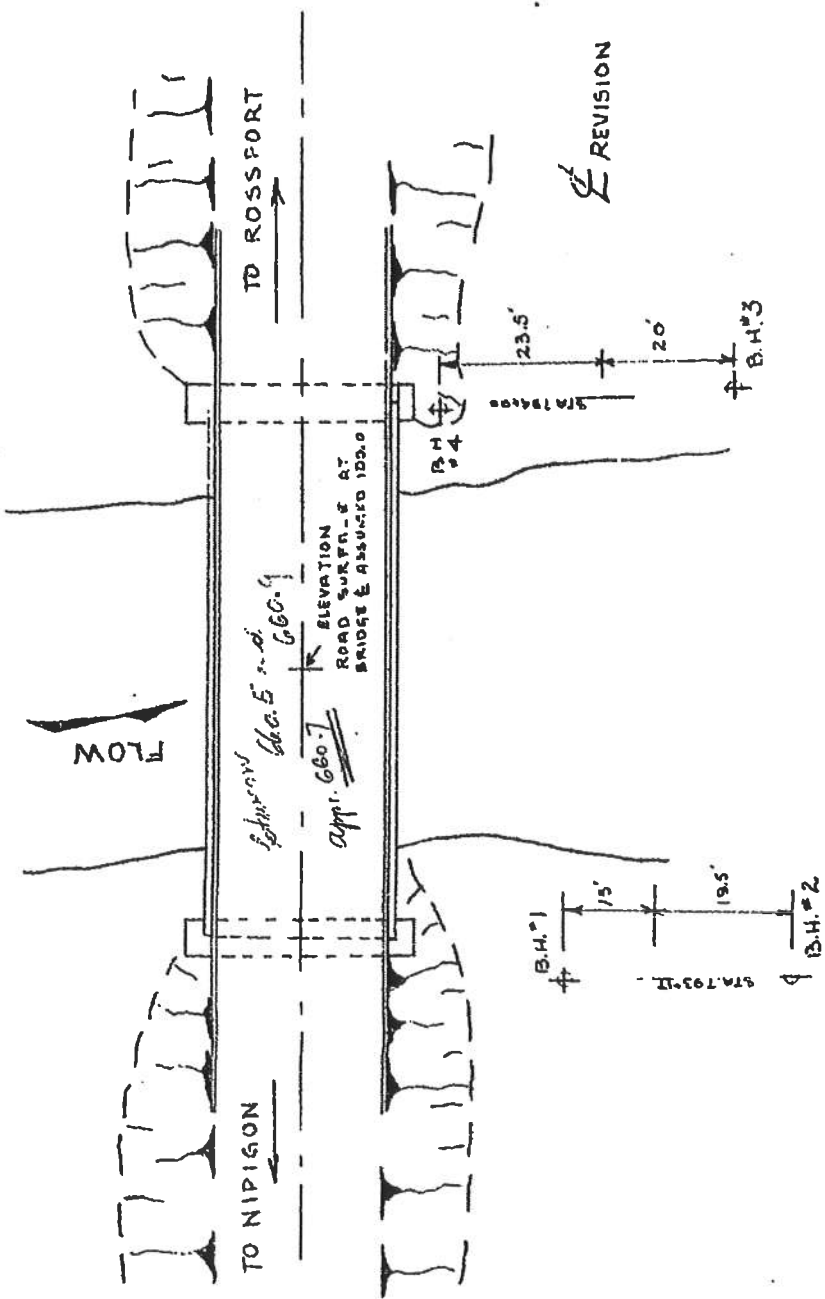
| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | JPR-01 | 6.40 | 195.61 |
| ■ | JPR-03 | 15.54 | 187.43 |



W.P.# 465-00-00
Prepared By AN
Checked By RPR

Appendix C

**Record of Borehole Sheets and Borehole Location Plan
(Previous Investigation)**



SUBSOIL SECTION

SCALE: 1 inch = 20 ft

PROJECT NO. J266

TROW SODERMAN AND ASSOCIATES

SOIL INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT JACKPINE RIVER CROSSING
LOCATION T.C.H. #17, District 19
HOLE LOCATION As on plan.

BOREHOLE NO. 2
FIELD SUPERVISOR A.P.
DRILLER H.J.
PREP. L.S.

BOREHOLE LOCATION AND DATUM 87.8 Road surface at
centre of existing bridge assumed 100.0

| DEPTH FEET | ELEV. FEET | STRENGTH AND PENETRATION RESISTANCE P.S.F. | BLOWS, FT. |
|---------------|---------------|--|------------|
| 0 | 87.8 | | |
| 10 | 82.3 | | |
| 20 | | | |
| 30 | | | |
| 40 | | | |
| 50 | | | |
| 34.1 | | | |

Ground surface.

Closely packed medium to coarse gravel with well rounded stones and boulders up to 3 ft in diameter.

End of borehole.

DRAWING NO.

3

LEGEND

- 2" DIA. SPLIT TUBE
- 2" SHELBY TUBE
- 2" SPLIT TUBE
- 2" DIA. CONE
- CASING
- 2" SHELBY
- 1/2 UNCONFINED COMPRESSION (QU)
- VANE TEST (C) AND SENSITIVITY (S)
- NATURAL MOISTURE AND LIQUIDITY INDEX
- LIQUID LIMIT
- PLASTIC LIMIT

CONSISTENCY

MOIST. CONTENT - % DRY WT

NATURAL UNIT WT. P.C.F.

TROW SODERMAN AND ASSOCIATES

soil investigations and soil mechanics consultation

02557

- 2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
1" DIA. CONE

2. " SHELBY
1-2 UNCONFINED COMPRESSION (QU)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND
LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

SAMPLE UNIT WT.:

[illegible][illegible]

BOREHOLE NO. 3
FIELD SUPERVISOR K.P.

As on plan 34.0 Road surface at centre of existing bridge assumed 100.0.

[illegible]

Existing ground surface.

[illegible]

W.J.V 82.3

Closely packed medium to coarse gravel with well rounded stones and boulders up to 3 ft in diameter.

Dens: medium sand with
fine to coarse gravel.
Occasional boulder.

end of hole.

23.0

42.0

PROJECT NO. J266

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT: Jackpine River Crossing

LOCATION: T.C.H. #17, District 19

DATE: 10/1/66

BOREHOLE NO. 4
FIELD SUPERVISOR K.P.
CRILLER H.J.
PREP L.S.
HOLE SEE ATTACHED DRAWING 96.8 Road surface at
centre of existing bridge assumed 100.0

| DEPTH FEET | ELEV. FEET | STRENGTH AND PENETRATION RESISTANCE P.S.F. |
|---------------|---------------|--|
|---------------|---------------|--|

Existing ground surface.

Closely packed medium to
coarse gravel with well
rounded stones and boulders H.L. ∇ 82.3
up to 3 ft in diameter.

End of hole.

96.8

10
20
30
40

DRAWING NO. 5

LEGEND

2" DIA. SPLIT TUBE

2" SHELBY TUBE

2" SPLIT TUBE

2" DIA. CONE

CASING

2" SHELBY

1/2 UNCONFINED COMPRESSION (QU)

WANE TEST (C) AND SENSITIVITY (S)

NATURAL MOISTURE AND

LIQUIDITY INDEX

LIQUID LIMIT

PLASTIC LIMIT

CONSISTENCY

NATURAL

SAMPLE UNIT WT.

P.C.F.

MOIST. CONTENT - % DRY WT.

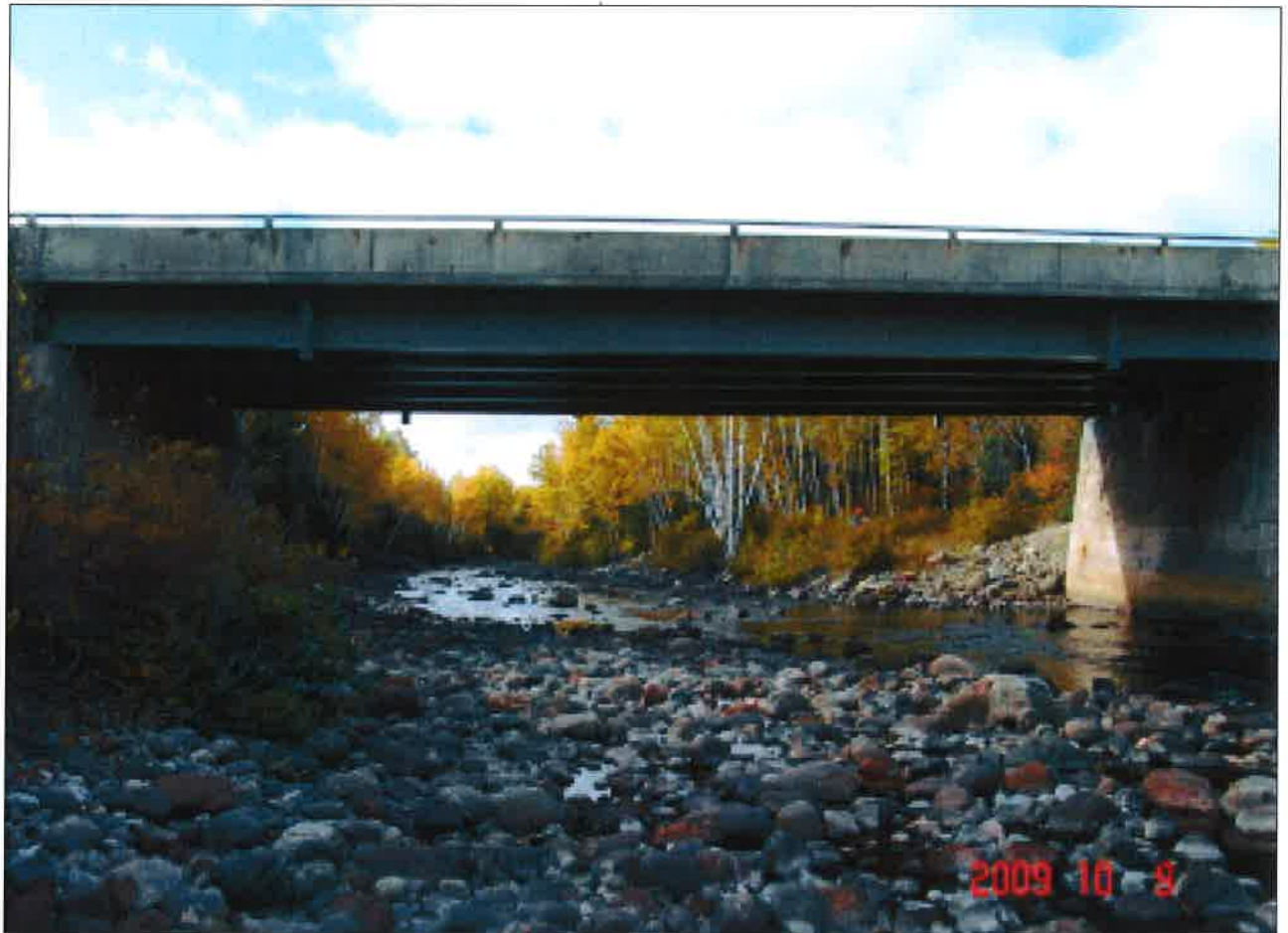
Appendix D
Site Photographs



Photograph 1 – Highway 17 and Jackpine River Bridge crossing



Photograph 2 – North side of the bridge



Photograph 3 – View of north elevation



Photograph 4 – View of south elevation



Photograph 5 – South side of the bridge



Photograph 6– Northwest view of the embankment



Photograph 7– Southeast view of the embankment



Photograph 8— Southwest view of the embankment

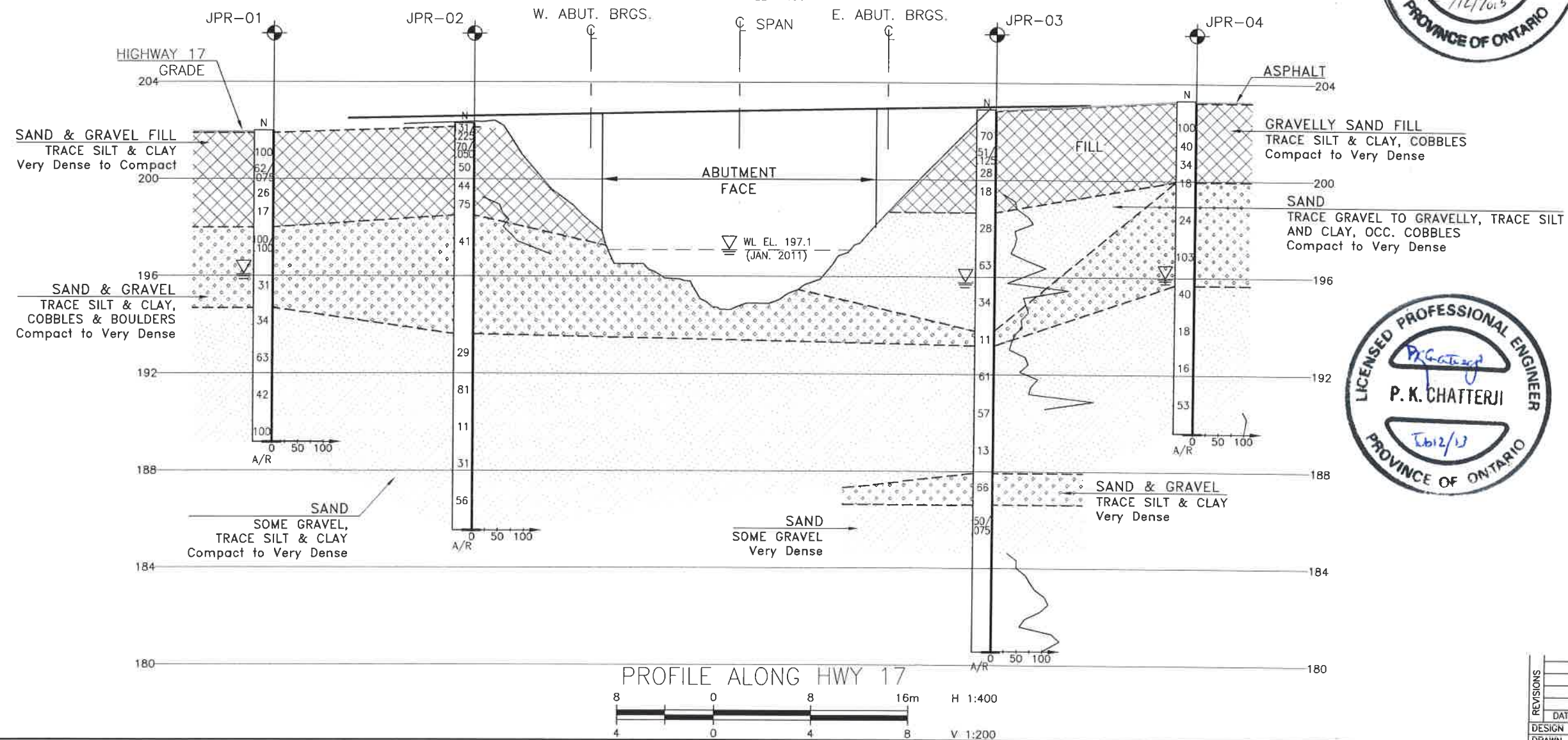
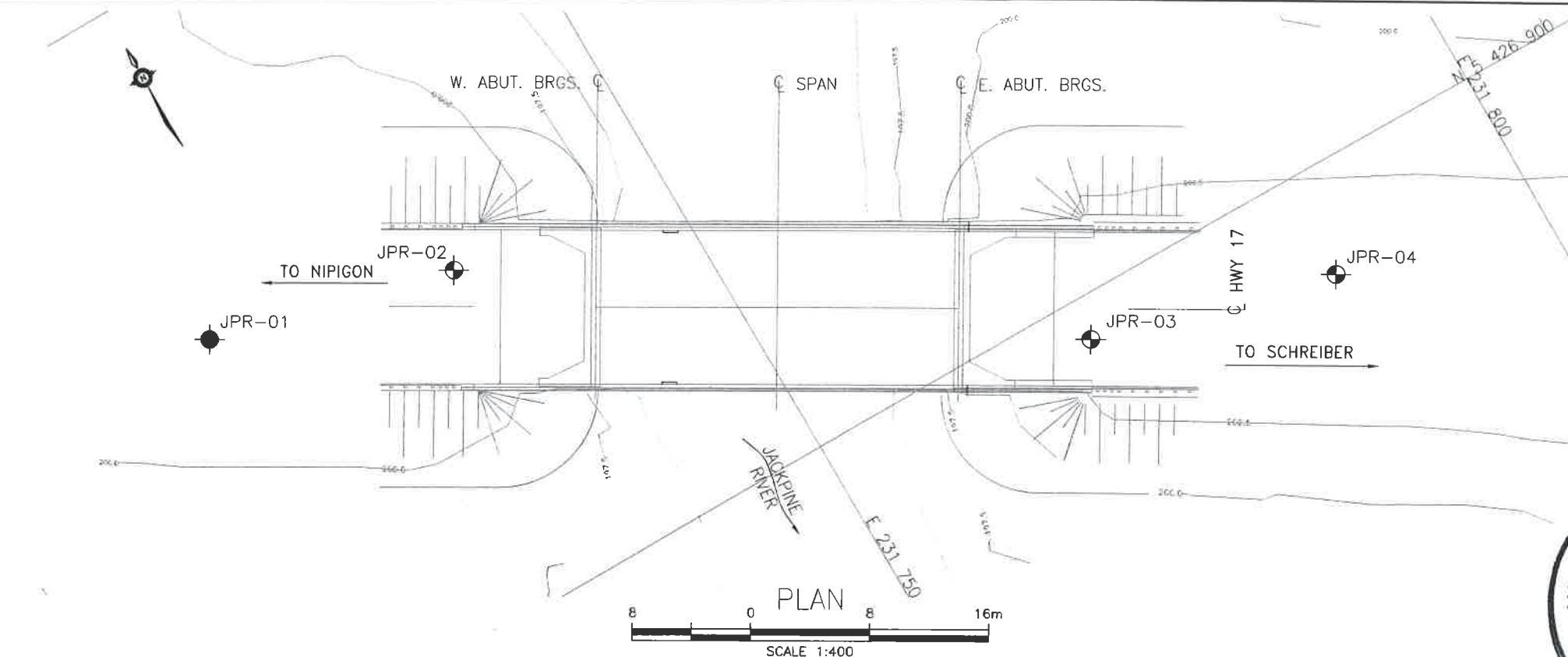
Appendix E
List of SPs and OPSS

1. List of Special Provisions and OPSS Documents Referenced in this Report

- SP 110S13
- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 1010
- OPSD 3101.150
- OPSD 3102.100

Appendix F

Drawing titled “Borehole Locations and Soil Strata”



METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 6070-09-01

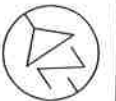
HIGHWAY 17
JACKPINE RIVER BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



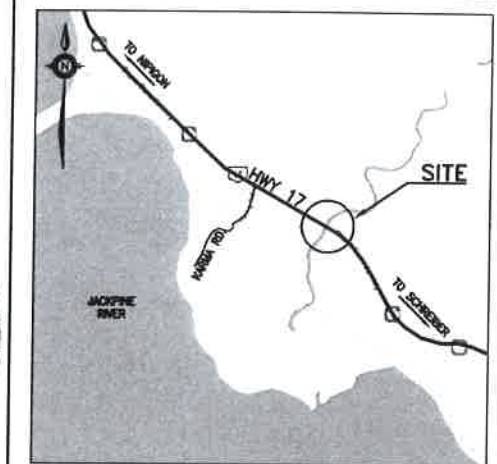
McCORMICK RANKIN
A member of MMM GROUP



THURBER ENGINEERING LTD.



SHEET
17



LEGEND

| | |
|------|---------------------------------------|
| ● | Borehole |
| ⊕ | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60' Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
| W | Water Level |
| HA | Head Artesian Water |
| P | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

| NO | ELEVATION | NORTHING | EASTING |
|--------|-----------|-------------|-----------|
| JPR-01 | 202.0 | 5 426 927.1 | 231 718.2 |
| JPR-02 | 202.3 | 5 426 922.8 | 231 734.8 |
| JPR-03 | 203.0 | 5 426 897.2 | 231 769.3 |
| JPR-04 | 203.3 | 5 426 892.8 | 231 785.8 |

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 42D-29

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|-----|----------------|
| DESIGN | RPR | CHK | RPR |
| DRAWN | AN | CHK | SITE |
| | | | STRUCT |
| | | | DWG 2 |
| | | | DATE JAN. 2013 |